Minutes from the Seismic Lessons-Learned Panel Meeting

November 14, 2012

Background

The Chief of Nuclear Safety (CNS) hosted the seventh meeting of the Seismic Lessons-Learned Panel (SLLP) at the DOE Forrestal Building on November 14, 2012. This panel was commissioned by CNS in August 2007, and it meets as requested by CNS. These meetings are intended for experts involved in seismic hazard assessments and facility seismic design across the DOE complex to share experience from their work. DOE site office staff responsible for seismic and other natural phenomena hazard (NPH) assessments are encouraged to participate.

Participants

George Antaki, Becht Engineering
Joel Blackman, Defense Nuclear Facilities Safety Board (DNFSB)
Said Bolourchi, Simpson Gumpertz & Heger
Kevin Coppersmith, Coppersmith Consulting, Inc.
Carl Costantino, CJC & Associates
Brent Gutierrez, DOE-Savannah River
Quazi Hossain, Lawrence Livermore National Laboratory
Joe Hunt, Babcock & Wilcox Y-12
Jeff Kimball, DNFSB
Chip Lagdon, DOE-CNS
Steve McDuffie, DOE-CNS
Elaine Merchant, Link Technologies
Gerry Meyers, DOE Office of Health, Safety, and Security (HSS)
Teresa Robbins, National Nuclear Security Administration (NNSA)-Y12 Site Office
Larry Salomone, consultant for the Electric Power Research Institute (EPRI)
Martha Shields, DOE Office of Nuclear Energy **
Debra Sparkman, DOE-CNS
Ali Tabatabai, Link Technologies
Raman Venkata, DOE-Office of River Protection
Tom Williams, NNSA

** Indicates participation by teleconference

Summary

Dr. McDuffie opened the workshop with a summary of the last SLLP meeting in May 2010. In the interim, CNS was involved with other activities, such as the issues with the System for Analysis of Soil-Structure Interaction (SASSI) software package, which some SLLP members have been supporting. He also welcomed Kevin Coppersmith, an expert in NPH assessment, as a new member of the Panel, and recognized the past work of Carl Stepp and Fred Loceff, who have chosen to resign from the Panel. Dr. McDuffie reviewed the purpose of the Panel as

described in the original charter from 2007. At the suggestion of Mr. Lagdon, Dr. McDuffie agreed to update the charter. Mr. Lagdon also welcomed the participants and highlighted the importance of the Panel's work over the past five years toward improving DOE's performance in seismic hazard characterization and design work.

Status of Savannah River Site (SRS) Probabilistic Seismic Hazard Analysis (PSHA) – Brent Gutierrez

Dr. Gutierrez provided a progress report on this ongoing project, which is currently scheduled for completion in January 2013. The current SRS PSHA was completed in 1997, and an update was initiated in 2005. The update effort did not initially make use of the Senior Seismic Hazard Analysis Committee (SSHAC) process as described in NUREG/CR-6372, and in 2007, some concerns were raised about the process. At that time, the Central and Eastern U.S. Seismic Source Characterization (CEUS-SSC) project for nuclear facilities was beginning, so the SRS PSHA update was suspended pending completion of the CEUS-SSC project. Initial hazard results from the 2007 work were higher than those of the 1997 PSHA, but an added design margin (a factor of 1.2) incorporated into new facility design was deemed adequate to bound the future hazard analysis. A SSHAC Level 2 process to refine CEUS-SSC regional hazard assessment for the SRS PSHA has been underway since 2010, and that work has confirmed that no local faults need to be added to the CEUS-SSC regional model. The CEUS-SSC model was finalized in January 2012, but the SRS PSHA was further delayed by an issue with the contractor performing the work.

New preliminary design spectra were provided for review in October 2012. These spectra use the site amplification functions from 2006; but, based on reviewer comments, the contractor will recalculate the site amplification functions before deriving the final spectra. The spectra also use the EPRI 2004-2006 ground motion prediction equations. SRS staff considered delaying completion so that the updated EPRI equations, expected in May 2013, could be used, but have decided against this. Once the new equations are available, their results will be evaluated as a sensitivity study while existing site facilities are analyzed against the new SRS design spectra.

Other NPH are also being re-analyzed at this time. Once all analyses are complete, the SRS nuclear facilities will be reviewed against the new hazard levels. These reviews will look at any impact on settlement, structural dynamic responses, and in-structure responses and impacts to safety systems. Site contractors will then recommend to DOE any further analysis or upgrade actions based on risk. Dr. Gutierrez noted that DOE currently has no criteria for judging facility risk and selecting facility upgrades based on increases in natural hazards.

In discussion after his presentation, Dr. Gutierrez noted that changes to the site amplification functions are due principally to changes in the bedrock hazard curves. Mr. Kimball stated that little guidance exists on how to develop site amplification functions, and such guidance would be very beneficial if included in a future update to ANSI/ANS-2.29.

Application of NUREG-2117 and the SSHAC Process to the Hanford Site-wide PSHA Project – Kevin Coppersmith

Dr. Coppersmith provided an overview of the ongoing Hanford PSHA project, which will replace the Hanford PSHA published in 1996. He discussed the motivation behind this project and its objectives, including the reasoning for performing the project as a SSHAC level 3. The Office of River Protection and Richland Operations Office elected to perform a new SSHAC level 3 PSHA because of the extensive new data, models, and methods available since the 1996 study. The project launched in April 2012, and it is scheduled for completion in August 2014. Coincidentally, in March 2012, the U.S. Nuclear Regulatory Commission (NRC) issued a letter pursuant to 10 CFR 50.54(f), requiring all western U.S. power reactors to have a SSHAC level 3 PSHA for their sites by 2015. One of these power reactors is Energy Northwest's Columbia Generating Station on the Hanford Site. The Hanford PSHA meets nearly all the needs of Energy Northwest to fulfill this regulatory requirement, so Energy Northwest formed a partnership with DOE to co-sponsor the project. The project will ultimately calculate the seismic hazard at the top of the uppermost basalt layer at six or more locations across the site. Surface ground motions will be calculated separately by DOE and Energy Northwest, with each responsible for its own soil column characterization and site response analysis. DOE may choose to delay the cost of collecting detailed geotechnical data at all locations where hazards will be calculated, whereas Energy Northwest does not have that option because of the NRC 2015 deadline.

Dr. Coppersmith reviewed the fundamentals of the SSHAC process and explained the structure of the Hanford PSHA project, with one technical integrator team devoted to seismic source characterization and another to ground motion characterization. He discussed the project schedule and then summarized the geology of the Hanford Site, describing how some of the information will be used by the technical integrators to develop seismic hazard curves. The project has already completed some hazard sensitivity studies, and he shared these results that are helping the technical integrators focus on the most hazard-significant issues. These results led the technical integrators to prepare a prioritized list of additional data collection tasks and analyses that will benefit the project, and in October 2012 the sponsors agreed to fund selected tasks. The Hanford PSHA is one of the first SSHAC level 3 projects to incorporate the 2012 guidance published in NUREG-2117, *Practical Implementation Guidelines for SSHAC Level 3 and 4 Hazard Studies*, and, as such, it will likely serve as a model for the world on conducting a site-specific, SSHAC level 3 seismic hazard analysis.

EPRI (2004, 2006) Ground Motion Model (GMM) Review Project – Larry Salomone

Dr. Salomone presented the status of an ongoing project sponsored by EPRI to update their 2004, 2006 ground motion model. A March 12, 2012, letter from the NRC to operating nuclear power plants requires a re-evaluation of seismic hazards at the plant sites. Plants in the CEUS must complete the re-analysis by September 2013. The CEUS-SSC report provides a current seismic source model, but EPRI recognized that the EPRI 2004, 2006 ground motion model may be outdated. The ongoing Next Generation Attention (NGA)-East project will not provide a new ground motion model until 2015 at best. EPRI recognized the need for a rapid review of the 2004, 2006 model and a possible update to incorporate new information. Any update must be

completed in time for the utilities to use the model in their seismic hazard re-evaluations due next September.

While polling ground motion experts on the available data and state of the practice, the project collected shear wave velocity measurements at 33 recording stations across the CEUS. These data help reduce uncertainty in future ground motion models, and they are being shared with NGA-East to benefit that project as well. Discussions with 11 ground motion modeling experts led to the conclusion in August 2012 that the 2004, 2006 model should be updated, so the project began working on the update immediately thereafter. Dr. Salomone noted that 80 percent of the earthquakes in the current database are not included in the database used in the EPRI 2004, 2006 model, so the data set behind the new results is much more robust. Several new ground motion models are being incorporated into the EPRI model, and others are being discarded. A feedback workshop to discuss preliminary results was held on October 17, 2012, and now updated hazard curves are being generated for the seven CEUS-SSC test sites. Comparison results from the new model and the 2004, 2006 model are slated to be available by December 31, 2012. Early indications are that the 2004, 2006 model overpredicts ground motions compared to the new model, which could lead to lower hazards at some locations. A final report will be made publicly available by EPRI in April 2013.

After the presentation, the Panel discussed the legitimacy of discarding some lower-magnitude earthquakes, sometimes through the use of a cumulative absolute velocity filter, when those events can contribute significantly to the hazard at frequencies above 10 Hz. High-frequency motions pose little hazard to structures, but they can damage electronic equipment.

Assessing Beyond-Design-Basis Seismic Events and Implications on Seismic Risk – Jeff Kimball

Mr. Kimball shared his perspectives on DOE's current approach to NPH analysis and design, specifically seismic risk implications of the performance goal approach. The performance goal approach defines a mean annual frequency of unacceptable performance and then dictates a design level for structures, systems, and components (SSCs) to meet the required performance. To ensure that seismic risk is acceptable, one must understand how a structure responds to progressing limit states, A through D, with an increase in seismic acceleration (and decrease in annual frequency of exceedance). Mr. Kimball noted that DOE uses design basis events, linked to accident analyses, to establish functional requirements for SSCs. These functional requirements should be linked to seismic design categories (SDCs) and limit states. Plutonium facilities are of particular interest. In most cases, the seismic risk at a plutonium facility is dominated by structural collapse, so such a failure should be considered in accident analyses. The DOE safety goal for latent cancer fatalities is 2E-6 per year, and adequate design margin may call for facilities to be designed such that latent cancer risk is less than 1E-7 per year. A plot of population dose versus latent cancer risk per year suggests that plutonium facilities should have a seismic collapse frequency no higher than 1E-4. Of course, population density and proximity to the facility are important aspects of this calculation. Mr. Kimball proposed that a facility with offsite dose consequences one or two orders of magnitude higher than a facility built to SDC-3 may not be adequately protective if it is designed to SDC-4, as the SDC-4 performance goal is only one-fourth the SDC-3 annual frequency of exceedance performance goal. Thus, the

ANS-2.26 standard from which these values are derived may not be adequately conservative. Mr. Kimball suggested that beyond-design-basis analyses consider the consequences from events with recurrence frequencies at least an order of magnitude lower than the design basis events. Moreover, risk analyses for all category 2 nuclear facilities could be more informed by examining the consequences of collapse, regardless of the collapse frequency. Finally, he recommended that the use of SDC-4 be limited to cases where the individual offsite doses exceed the 25 rem evaluation guideline by only an order of magnitude. For any higher consequences, DOE should quantify the facility collapse frequency to ensure seismic risk is acceptable.

Beyond-Design-Basis Post-Fukushima Seismic Activities at NRC – George Antaki

Mr. Antaki discussed the status of three initiatives NRC is taking with nuclear power plant license holders. The three initiatives are: the Fukushima Near-Term Task Force (NTTF) recommendation 2.3, seismic walkdowns; the availability of emergency equipment, or FLEX; and NTTF recommendation 2.1 on seismic probabilistic risk assessment (PRA). On May 31, 2012, NRC endorsed industry guidance on performing seismic walkdowns, EPRI 1025286. Meanwhile, NRC created Inspection Manual 2515/188 to guide NRC staff oversight of seismic walkdowns. Mr. Antaki explained the screening steps for placing equipment onto one of two seismic walkdown equipment lists. List one is for safety SSCs, whereas list two is just for safety SSCs related to spent fuel operation. The combined lists are expected to contain between 100 and 120 pieces of equipment. The FLEX initiative for emergency equipment envisions portable power and water supply equipment that can be stored in a central location and quickly mobilized to a plant in need. Such equipment would be designed to a ground motion twice the level of a safe shutdown earthquake (SSE). The final scope of FLEX is yet to be determined. Mr. Antaki proposed that a FLEX approach could be beneficial for DOE. Regarding the third initiative, he believes that all power plants are preparing to perform seismic PRAs, although the seismic margin assessment is an alternate path allowed by NRC. He notes that some preliminary comparisons between existing SSE spectra and new ground motion response spectra (GMRS) show the GMRS significantly exceeding the SSE at frequencies above 20 Hz. Remaining technical issues are the need to develop fragility curves for various equipment types and addressing components sensitive to high frequencies.

Should High-Hazard Structural Seismic Design Meet National Consensus Building Codes? – Said Bolourchi

Dr. Bolourchi has noticed that some high-hazard facilities can be built in accord with their applicable design codes (e.g., American Society of Civil Engineers (ASCE) standard 43), but they may not meet certain aspects of the International Building Code (IBC) and ASCE 7 that apply to non-hazardous facilities. For example, for certain structural systems, ASCE 7 specifies limits on building heights and structural irregularities, whereas ASCE 43 has no such limits. For minimizing irregularities and maximizing redundancies, ASCE 43 provides only suggestions, whereas the IBC and ASCE 7 provide direct guidance. Dr. Bolourchi made no recommendations as part of this presentation; he merely wanted to alert the Panel to these facts. George Antaki noted that ASCE 43 requires a more rigorous design process with peer review. Joe Hunt

commented that ASCE 7 assumes that designers may miscalculate base shear and drift, so it includes limits on the reduction of base shear and drift.

Impact of Structure-Soil-Structure Interaction (SSSI) on a Heavy Structure – Said Bolourchi

Dr. Bolourchi had an additional presentation on the seismic response of a heavy structure when it is located adjacent to another heavy or moderately heavy structure. He used SASSI to calculate the interactions of surface structures (the subtraction method was not used) in both stiff and soft soil. In-structure response spectra (ISRS) within a heavy structure were compared for four scenarios: the heavy structure alone, the heavy structure adjacent to another heavy structure (about 6 feet separation), the heavy structure adjacent to a moderately heavy structure, and the heavy structure remotely spaced from another heavy structure. The analysis found that the SSSI effects can be significant when the structures are closely spaced, regardless of whether the adjacent structure is heavy or moderately heavy. In addition, softer soil conditions have a greater impact on SSSI responses. The ISRS calculated from just soil-structure interaction (SSI) bound the ISRS calculated from SSSI in stiff soil conditions. However, the ISRS from SSI are generally not conservative compared to the SSSI responses in soft soil.

A Progress Report on ASCE 4 Committee Activity – Carl Costantino

Dr. Costantino provided a brief verbal update from the recent ASCE 4 committee meeting. The new ASCE 4 standard on seismic analysis of nuclear structures is nearing completion, although work remains on chapters 2 and 5. Dr. Costantino also mentioned he is working with the NRC on an update to the reactor Standard Review Plan. He could not discuss that ongoing work at this time, but he did say the update will address the topics of differential settlement and wall pressures.

Major DNFSB Staff Concerns Regarding DOE-STD-1020-2012, Chapter 9 – Joel Blackman

Dr. Blackman provided his views on Chapter 9 in the new DOE-STD-1020-2012, *Natural Phenomena Hazards Analysis and Design Criteria for DOE Facilities*, which was issued in December 2012. Chapter 9 provides criteria and guidance for design and evaluation of SSCs for facilities undergoing major modifications, 10-year reviews and updates of NPH assessments, facility condition assessments, and evaluations and possible upgrades to SSCs resulting from new hazard assessments. Dr. Blackman and other DNFSB staff are generally pleased with the STD-1020 revision, but not with the new Chapter 9. One concern is that Chapter 9 requirements apply only to facilities with SSCs in NPH design category 3 or higher. Another is that Section 9.1 allows case-by-case exceptions to the Standard, but provides no explanation of a process for justifying an exception. Regarding Section 9.2 and the guidance on determining whether an NPH assessment needs an update, Dr. Blackman is concerned that users of the Standard are being asked to render a judgment on the outcome of a new assessment before it is performed. Users should err on the side of performing a new assessment rather than not. Dr. Blackman and other DNFSB staff members have numerous concerns with Section 9.3 on facility condition assessments. He provided a flowchart outlining a recommended process for evaluating facility SSCs if a new assessment yields a higher NPH. One of the key omissions from Chapter 9 is a requirement to develop acceptance criteria and an analysis methodology for SSC evaluations.

Moreover, the Standard is not adequate in requiring deficiencies to be addressed; upgrade actions are left as discretionary. He recommends that without a formal process for managing design upgrades, all SSCs found deficient should be upgraded to current standards.

After this presentation, Mr. Antaki stated that Dr. Blackman's comments were excellent, and a rewrite of Chapter 9 should follow the flowchart he provided. Mr. Antaki also recommended that, in light of an increased NPH, existing SSCs should undergo two evaluations as to whether: 1) the design meets current code requirements, and 2) there is a high confidence of a low probability of failure (HCLPF) in a design basis event. If these two criteria are not met, corrective action should be taken. Mr. Antaki also stated that Chapter 9 should be written more concisely, and if DOE wants to leave certain topics to contractor discretion, those should be explicitly stated.

The meeting closed with a brief discussion of whether the Oak Ridge site should expend the effort to calculate new seismic hazard curves using the CEUS-SSC model if the curves generated in 2003 with the U.S. Geological Survey source model can be shown to be bounding. Opinions were varied.